Actuaries Summit

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Coherent Capital Framework for Longevity Risk

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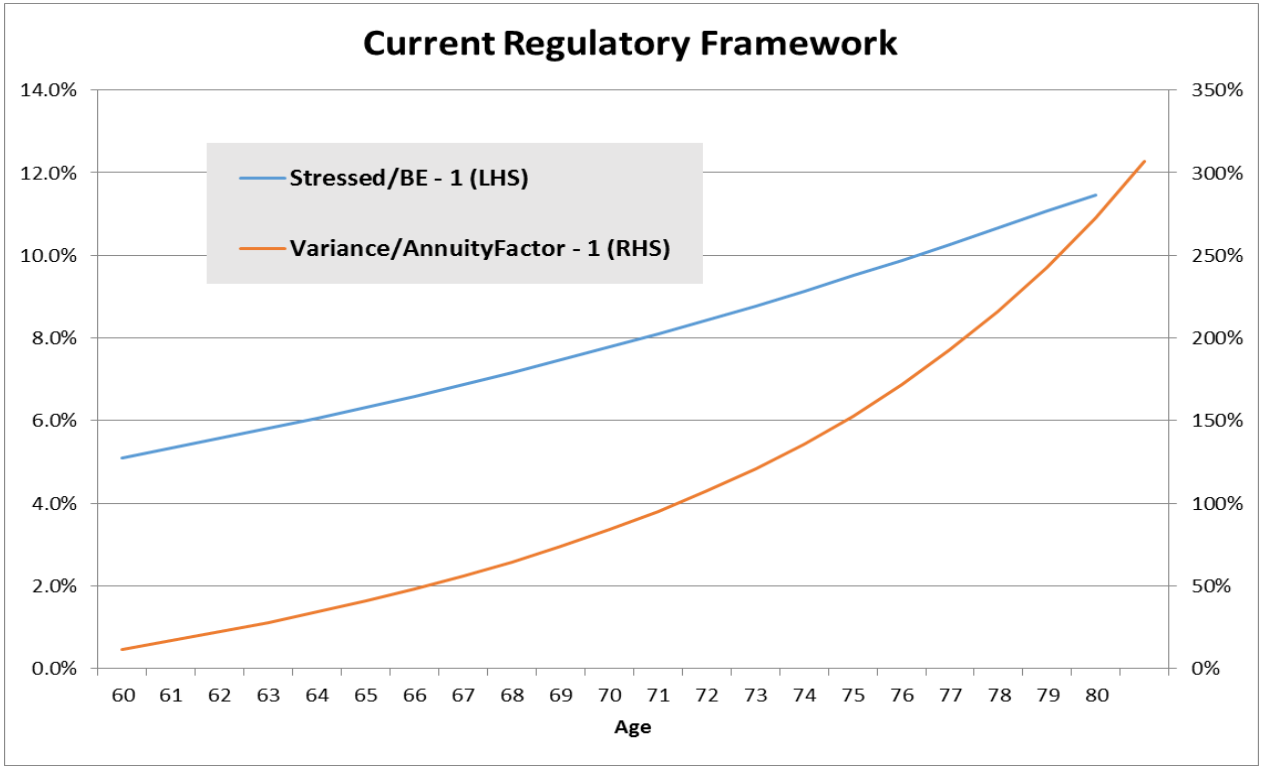
Intro – LAGIC & Solvency II

- **Longevity risk**
  - 99.5% sufficiency
  - One year horizon
  - Single parameter of 20% permanent reduction to qx
  - Merits:
    - Simple
    - Tie in with Variance of Annuity (shape?)

Intro – LAGIC & Solvency II

- **Illustration**



Intro – LAGIC & Solvency II

- **Issues to discuss**
  - Non-linear effect
    - Analogous to IP termination rates: appropriateness of a uniform stress?
  - Calibration (Systematic/Portfolio/Individual)
    - Possibility of decomposing?
    - Variance of Annuity only measures the individual risk
    - For LI, Random & Future stress calibrated at portfolio level whilst event stress from systematic shock

Intro – LAGIC & Solvency II

- **Issues to discuss (cont.)**
  - Time horizon
    - One year under Solvency II given opportunities for short term management actions
    - Too onerous if life-time horizon, for example Life Expectancy for a 60 year old male is 84 measured at 50 percentile (by definition), but >100 at 99.5 percentile

Intro – A Coherent View

- **Proposed aspects for a coherent framework:**
  - i. Systematic approach
    - Systematic risk (model risk, population trend, statistical fluctuation and shocks)
    - Unsystematic risk (portfolio level)
    - Bayesian updating based on experience
  - ii. Consistent with regulatory regimes
    - 99.5% sufficiency
    - Pillar I & II

Intro – A Coherent View

- **Proposed aspects for a coherent framework:**
  - iii. Business issues
    - Time horizon to tie in with business plan and ability to raise capital, given annuities are long term risk business without repricing rights/limited management actions
  - iv. Risk measure
    - Diversification/Heterogeneity
    - Selection effects

Key Literature

Longevity capital

- Solvency II & LAGIC
- Olivieri & Pitacco (2009)
- Borger (2010)
- Plat (2011)
- Richards et al (2012)
- Jarner and Møller (2015)

Mortality studies

- Vaupel et al (1988)
- Foster (1991)
- Lee-Carter (1992, 2000)
- CBD (2006)
- Term structure

Credibility theory

- Bühlmann (1967, 1970)
- West and Harrison (1997)

Best Estimate Assumptions

- Starting point: population/industry/company data
- Adjustments to trend:
  - Assume trend follows population
  - Update using Buhlmann approach
    - only for duration >5 year to separate out elimination of initial selection effect
    - Z x experience trend + (1 – Z) x population trend

$z = \frac{N}{N+k}$ assigned to experience

where N = number of periods in the experience investigation

$k = {}^{experience\ variance}/_{population\ (basis)\ variance}$

Best Estimate Assumptions

- Adjustment for selection effects
  - Need to consider initial & permanent
  - Subjective initially & updated with experience using Bayesian techniques

Building blocks

Allow for:

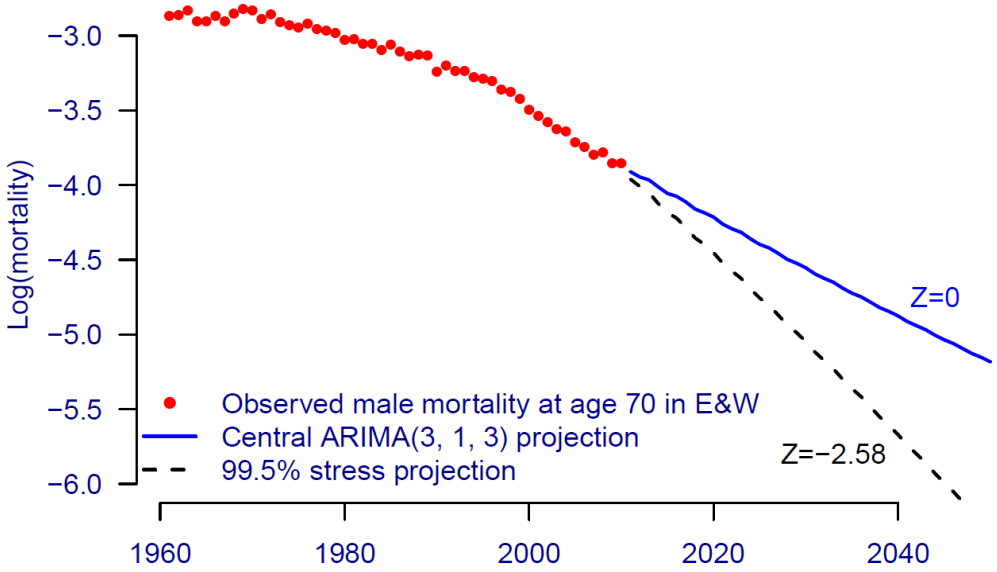
- Mis-estimation of the trend
- Mis-estimation of selection effects
- Random fluctuations in deaths

Capital – systematic trend risk

- "Random" stress
  - Lee-Carter for example: ln(m(x, t)) = $\alpha_x + \beta_x \cdot \kappa_t + \varepsilon_{x,t}$
  - Randomness in κ_t and noise $\varepsilon_{x,t}$
  - Increase with time
  - 99.5% CI envelop

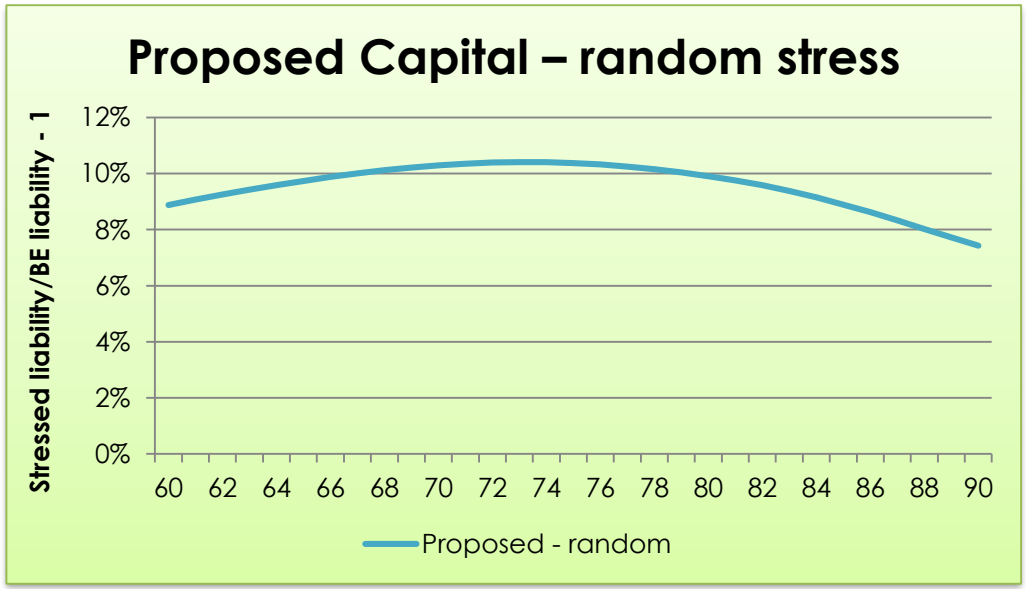
Capital – systematic trend risk

- "Random" stress illustration (systematic noise)



Capital – systematic trend risk

- "Random" stress:



Capital – systematic trend risk

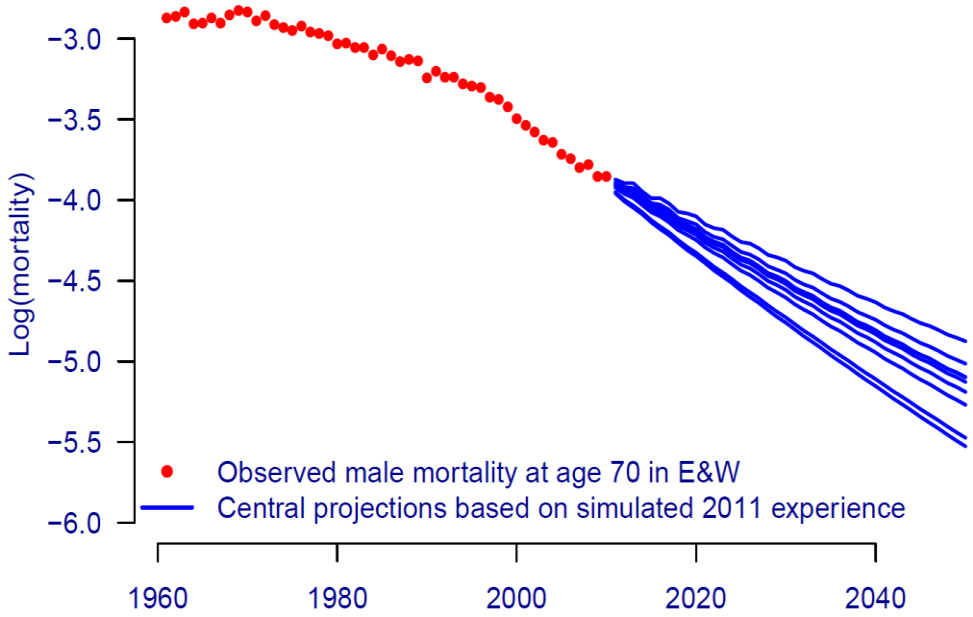
- Trend mis-estimation:
  - Mis-estimation of the central estimate line
  - Risk that when mis-estimated, the chance of further mis-estimation increases, which will result in need of more capital (a '**momentum**' effect)
  - Consider business plan cycle for capital raising
  - Need enough capital at the end of the period if poor result leads to re-estimate the trend

Capital – systematic trend risk

- Trend mis-estimation:
  - A 'rolling' projection approach with stressed estimates
    - Similar to Bayesian updating
    - Refitting projection model using stressed forecast while reducing one historical data point
    - Repeat for n periods
    - Normally n consistent with business plan period (3-5 years)
    - Stress over n periods total 99.5%, where each period can take $(1 - {}^{1}/_{200})^{1/n}$

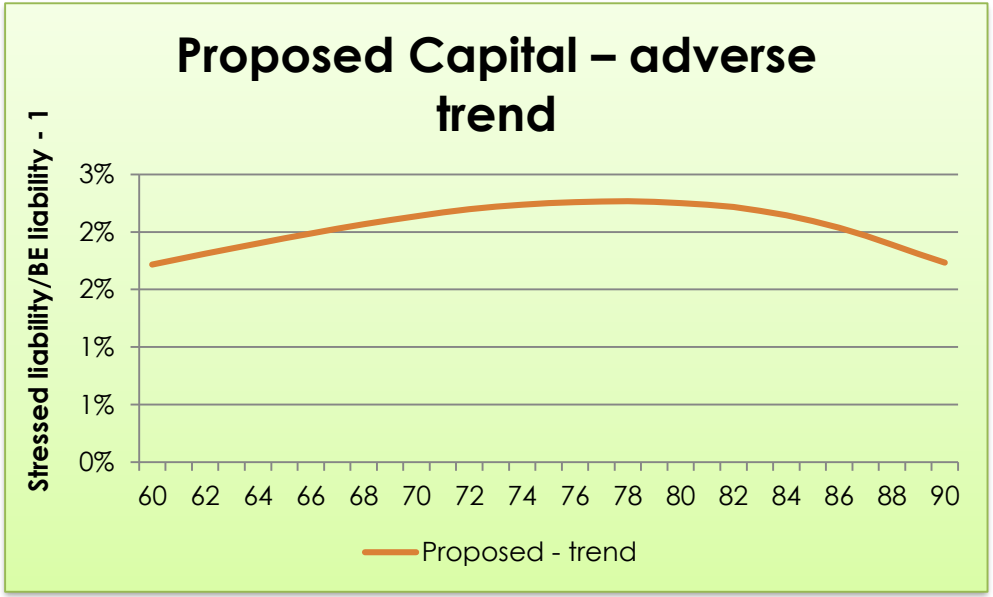
Capital – systematic trend risk

- Trend mis-estimation: an illustration



Capital – systematic trend risk

- Trend mis-estimation:



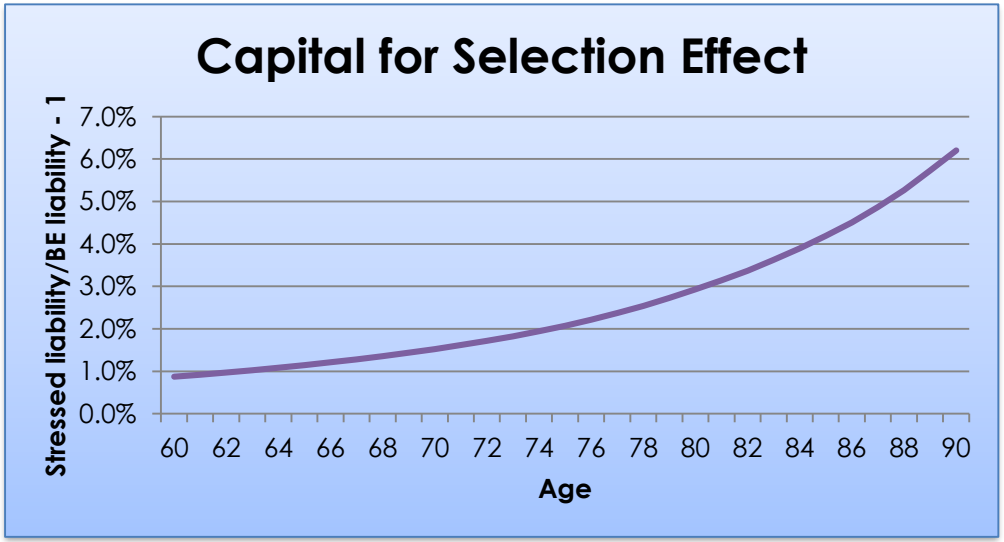
Capital – portfolio risk

- Selection
  - Initial conservatism to be updated with experience
  - Example

Year	Base Selection Factor (Prior estimate)	Capital Margin	Stressed Selection Factor (Based on prior confidence)
1	0.50000	20%	0.40000
2	0.60000	15%	0.51000
3	0.70000	10%	0.63000
4	0.80000	5%	0.76000
5+	0.90000	3%	0.87300

Capital – portfolio risk

- Selection: as an illustration



Capital – portfolio risk

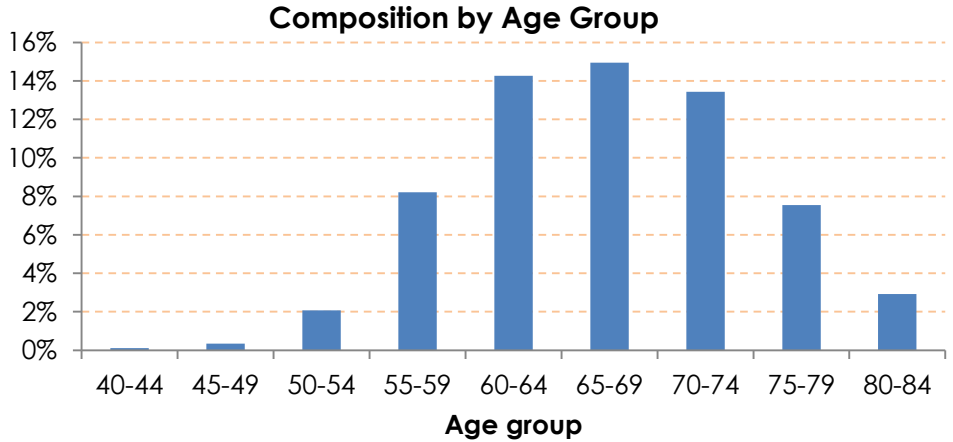
- Portfolio specific risk margin
  - Volatility of observed rates (part of Solv II directive)
  - Diversifiable
  - Driven by
    - Portfolio size
    - Portfolio composition
    - Bayesian updates of priors as experience develops

Capital – portfolio risk

- Portfolio specific risk margin (cont.)
  - uncertainty around BE assumption setting (the risk factor)
  - portfolio experience (the credibility)
  - reference:
    - recall *IAAust Risk Business Capital Taskforce (2008)*
    - also *Jarner and Møller (2015)*

Capital – portfolio risk

- an example for illustration
  - Portfolio male/female = 40%/60%
  - Age groups



Capital – portfolio risk

- an example for illustration(cont.)
    - Portfolio decrements over five-year experience analysis:

Year	Portfolio q_x
1	0.017197
2	0.019627
3	0.022230
4	0.024872
5	0.027723

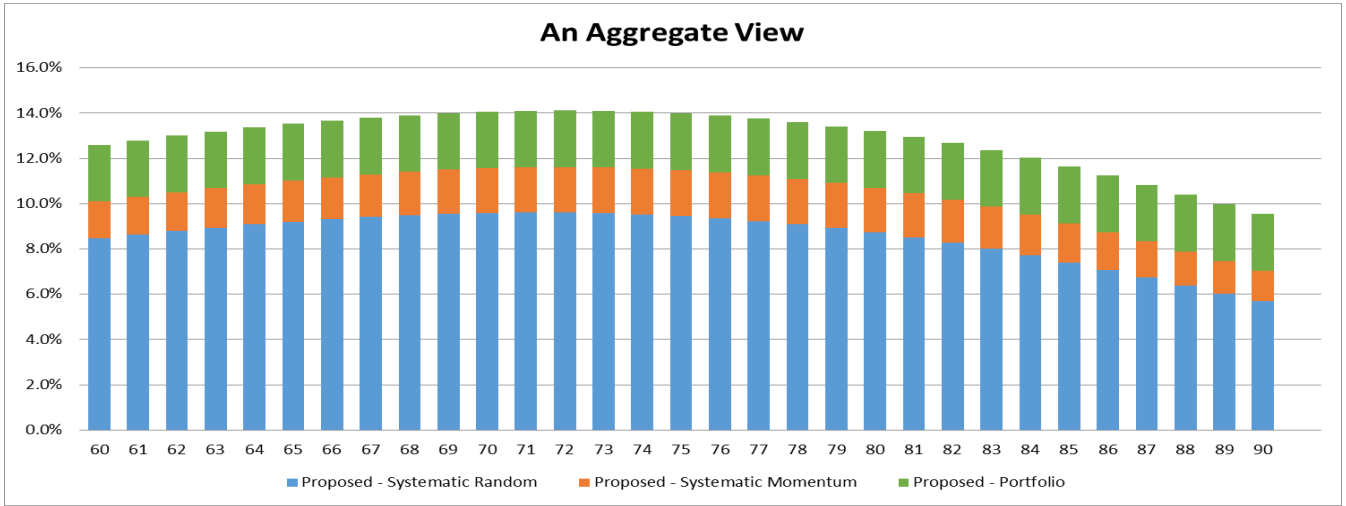
Capital – portfolio risk

- an example for illustration(cont.)
    - Margins derived

Portfolio Size	100	500	1,000	5,000	10,000	20,000	50,000	100,000
Capital Margin	70%	31%	22%	10%	7%	5%	3%	2%

Results in a nutshell

- As an illustration (an aggregated view)
  - Capital charge as a percentage to the best estimate liability for an immediate annuity commencing at each age between 60 – 90
  - Portfolio assumed to contain 50,000 independent policies



Further Issues for Discussion

1. Time horizon: one year or business plan period or ..?
2. Population trend appropriate for portfolio?
3. Sources for selection effect derivation
4. Implications for
   - DLAs
   - GSAs